FOREST RESEARCH REPORT

NOVA SCOTIA DEPARTMENT OF LANDS AND FORESTS
P.O. BOX 68, TRURO, N.S. B2N 5B8

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SEASONAL INFLUENCE ON PLANTATION SURVIVAL AND GROWTH ON MAINLAND NOVA SCOTIA

INTRODUCTION

Many of Nova Scotia's forest stands are inadequately stocked with natural softwood regeneration after harvesting. In fact, Snow (1982) estimated that 30% of 5 to 6 year-old softwood cutovers in Nova Scotia are less than 60% stocked with naturally regenerated commercial species. To restore production on these sites requires the planting of approximately 30 million trees per year.

From a logistics and operational viewpoint, it would be more efficient to plant throughout the growing season rather than only during spring and early fall. In some regions of Canada, survival and height have been found to vary according to planting date, whereas other studies have indicated that planting can take place from spring, throughout the summer months and into the fall without adversely affecting growth or survival (Anon., 1984; McClain, 1981; Mullin, 1968; Wood and Dominy, 1985). A study undertaken on the Cape Breton Highlands of Nova Scotia showed that white and black spruce multipots can be planted throughout the growing season without adversely affecting survival or growth (NSLF, 1988). To determine whether the same is true for mainland Nova Scotia, where moisture deficiencies are more common, a trial involving 7 species was established at Delaney Settlement, Colchester County (45°28'N, 63°18'W).

SITE DESCRIPTION

The 4 hectare, moderately undulating site at Delaney Settlement (elevation 168 m A.S.L., southern exposure) is covered with a gravelly sandy loam soil, derived from sandstone and conglomerate (Cann and Wickland, 1950). Prior to harvest in 1986, the site supported a cover of mature softwood. Site preparation consisted of piling slash into rows using a brush rake, followed by burning.

The climate in this region is characterized by cool wet springs and warm summers, with occasional dry periods where soil moisture is limiting (Dzikowski *et al*, 1984). During 1987, 528 mm of rain fell in this region between May 4 and November 2. The average weekly rainfall for this period was 20 mm and varied from 0 mm for the week of July 6, to 48 mm during the week of October 19 (Figure 1). Of

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Nova Scotia Department of Lands and Forests

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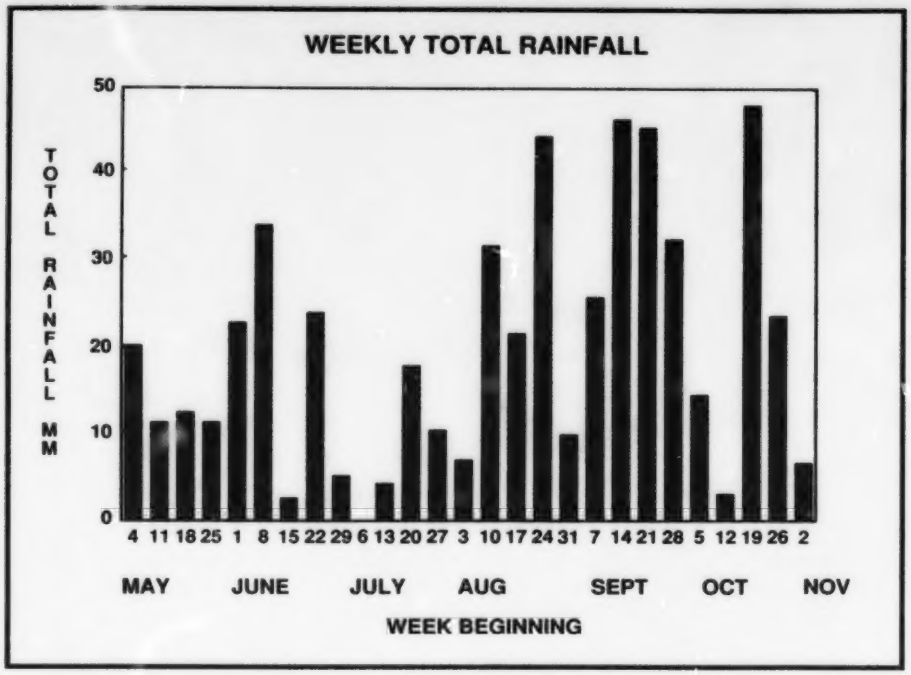


Figure 1. Weekly total rainfall between May 4 and November 2, 1987 (recorded at the Truro weather station by Environment Canada).

this total, approximately 53% fell between the period of Sept. 1 and Nov. 2. The corresponding province-wide averages, for the same period, were 595 mm for total rainfall and 22 mm for mean weekly rainfall.

METHODS

The experimental site was divided into 42 blocks: 30 blocks measured 29x29 metres and 12 were 11x29 metres. Three blocks were assigned to each of 14 bi-weekly planting dates, beginning May 4 and ending November 2, 1987. No planting was carried out on June 29 due to a shortage of nursery stock. Within the blocks up to 6 species were planted, each arranged in 2 rows of 15 trees. The species planted included: black spruce (*Picea mariana* (Mill) B.S.P.), white spruce (*Picea glauca* (Moench) Voss.), red spruce (*Picea rubens* (Sarg.), Norway spruce (*Picea abies* (L.) Karst.), white pine (*Pinus strobus* (L.), red pine (*Pinus resinosa* Ait.), and eastern larch (*Larix laricina* (Du Roi) K. Koch). The availability and quality of the planting stock in the nursery determined which of these species were planted on a given date. Red and black spruce were the only species planted in every session (see Table 1).

The trees were grown in multipots at the Strathlorne Forest Nursery (Inverness Co., Cape Breton) or the Wittenburg Forest Nursery (Colchester Co.). Seeding took place between May of 1986 and March of 1987. Stock quality measurements (heights, diameters, shoot/root ratios and oven dried weights) were recorded at the time of each planting (Appendices I-II). All trees were planted with a dibble at 1.8 x 1.8 metre spacing.

The planting was divided into 3 sessions according to the nursery schedule. They are referred to as spring (May 4-June 15), summer (July 13-Aug. 10) and fall sessions (Aug. 24-Nov. 2).

Table 1. The number of blocks planted by date and species during the 1987 seasonal trial at Delaney Settlement.

Date		rS	bS	wS	nS	rP	wP	eL
Spring								
May	4	3	3	3	3	0*	3	3
May	19	3	3	3	3	0*	3	3
June	1	3	3	3	3	0*	3	3
June	15	3	3	3	3	0*	3	3
Summer								
June	29	0*	0*	0*	0*	0*	0*	0*
July	13	3	3	0*	0*	3	0*	0*
July	27	3	3	0*	0*	3	0*	0*
August	10	2*	3	0*	0*	3	0*	0*
Fall								
August	24	3	3	3	3	3	0*	3
September	8	3	3	3	3	3	0*	3
September	22	3	3	3	3	3	0*	3
October	5	2*	2*	2*	3	3	0*	2*
October	19	3	2*	3	3	3	0*	3
November	2	3	3	3	3	3	0*	3

rS = red spruce
bS = black spruce
wS = white spruce
nS = Norway spruce
rP = red pine
wP = white pine
eL = eastern larch

* Blocks not planted due to shortage of nursery stock

ASSESSMENT

An assessment of survival and height growth was carried out in November of 1988, the first year following planting. Survival was based on a 100% tally. Average leader length and total height were determined by measuring 10 randomly selected trees, per species, per block. An estimate of the severity of competing vegetation was also recorded.

Survival was expressed as both observed and projected, where:

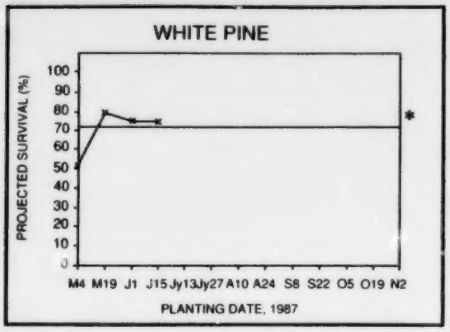
$$\text{observed survival} = \frac{\text{live trees}}{\text{live + dead trees}} \times 100$$

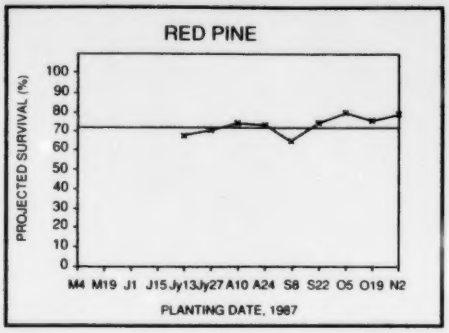
$$\text{projected survival} = \frac{\text{live trees}}{\text{live + dead + missing trees}} \times 100$$

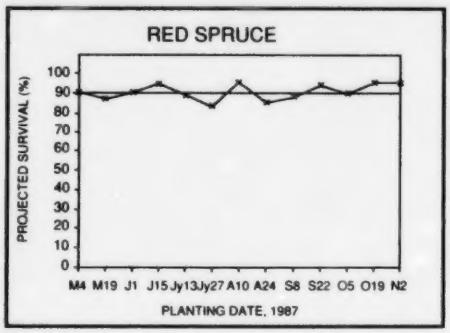
RESULTS

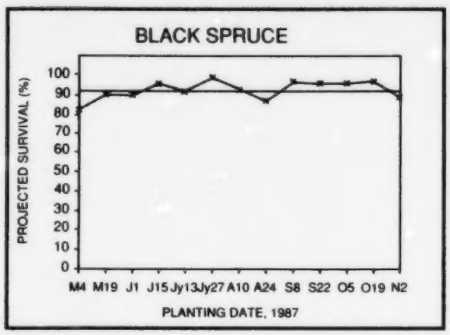
SURVIVAL

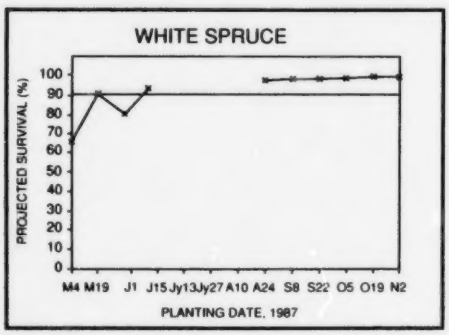
Figure 2 shows the projected survival rates by planting date and species. Overall, each of the species displayed a slightly higher survival at later planting dates. White spruce and Norway spruce showed the largest increase in projected survival from the spring to fall planting sessions. For example, wS averaged 83% projected survival over all spring planting dates and 98% for all fall plantings (Table 2, Appendix IV). At the other extreme, red

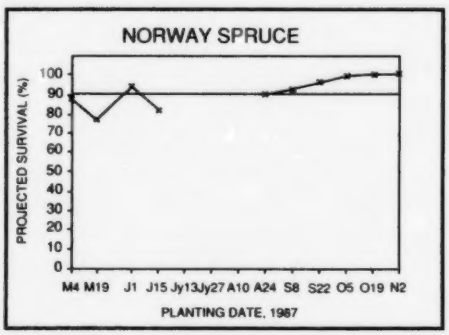


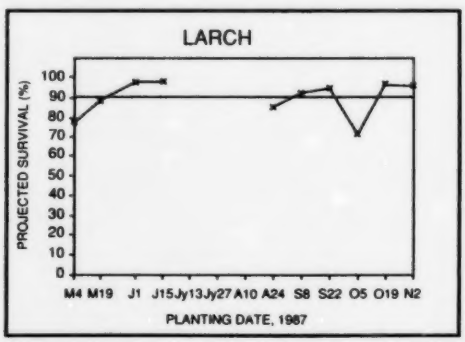












*** Average Projected Survival (%) Over All Dates**

Figure 2. Projected survival (%) by species and planting date, based on assessments conducted in November of the year following planting.

Table 2. Projected survival (%), observed survival, (%) and average leader length (cm) by species and season of planting (based on assessments conducted in November of the year following establishment, 1988).

	Spring [1]			Summer [2]			Fall [3]			Average		
Spec	Projected [4] Survival	Observed [5] Survival	Average Leader	Projected Survival	Observed Survival	Average Leader	Projected Survival	Observed Survival	Average Leader	Projected Survival	Observed Survival	Average Leader
bS	89	92	17	94	96	12	93	96	11	92	95	14
rS	93	96	18	91	94	9	94	96	10	92	95	13
wS	83	93	16	-	-	-	98	99	9	91	97	13
nS	85	88	11	-	-	-	95	98	9	90	93	10
rP	-*	-	-	70	79	6	72	82	7	71	80	7
wP	71	78	10	-	-	-	-	-	-	71	78	10
eL	92	97	25	-	-	-	90	99	12	91	98	19

1 May 4 - June 15
2 July 13 - August 10
3 August 24 - November 2
4 Projected Survival = Live trees / (Live trees + Dead + Missing) * 100
5 Observed Survival = Live trees / (Live trees + Dead) * 100
* Not planted

and black spruce showed the smallest increase from spring to fall planting dates (e.g. Table 2 shows rS had an average projected survival of 93% in the spring versus 94% in the fall).

Some of the species planted showed fluctuating survival rates within planting session as well as between sessions. For example, Norway and white spruce survival varied by as much as 17 and 30% respectively within the spring planting session but stabilized during the fall planting session. Larch, on the other hand, showed increased survival by date within both the spring and fall sessions. Finally, the white pine and white spruce planted on the earliest spring planting date (May 4) resulted in poor survival as compared to the other planting dates. In fact, the average projected survival for white pine on the May 4 planting date was only 53%, compared to 75-80% for the other spring planting dates, while comparable figures for white spruce were 65% versus 81-91% survival.

There was also variation in survival by species. Over all planting dates, red and black spruce showed the highest projected survival rate, both at 92% (Table 2). The pines (white and red) showed the lowest projected survival (71%). Field observations indicate the lower survival of the pines may have been as a result of browsing during the fall of 1987.

Vegetative competition was not a factor in overall survival for any of the species, as only 6% of the seedlings, on average were categorized as severely competed against.

On average, over all planting dates, only 2% of the trees were missing. In cases where survival decreased noticeably (Oct. 5 for eL; May 4 for wS; May 4 for wP) the percentage varied between 6 and 8%. Visual observation of the planting site indicated browsing to be the primary cause of this increased mortality.

LEADER GROWTH

Average 1988 leader growth, by planting date and species, is shown in Figure 3. Overall, most species showed a decreasing trend in leader growth with later planting dates (Table 2, Appendix V). This trend was most pronounced for larch, where average leader growth was 25 cm for the spring session, as opposed to 12 cm for the fall plantings. Norway spruce displayed the least fluctuation in leader growth between the spring and fall sessions (11 versus 9 cm).

Generally larch had the longest leaders and the pines the shortest. The largest differences occurred in spring planted trees, where leader growth for larch averaged 25 cm, versus 10 cm for white pine.

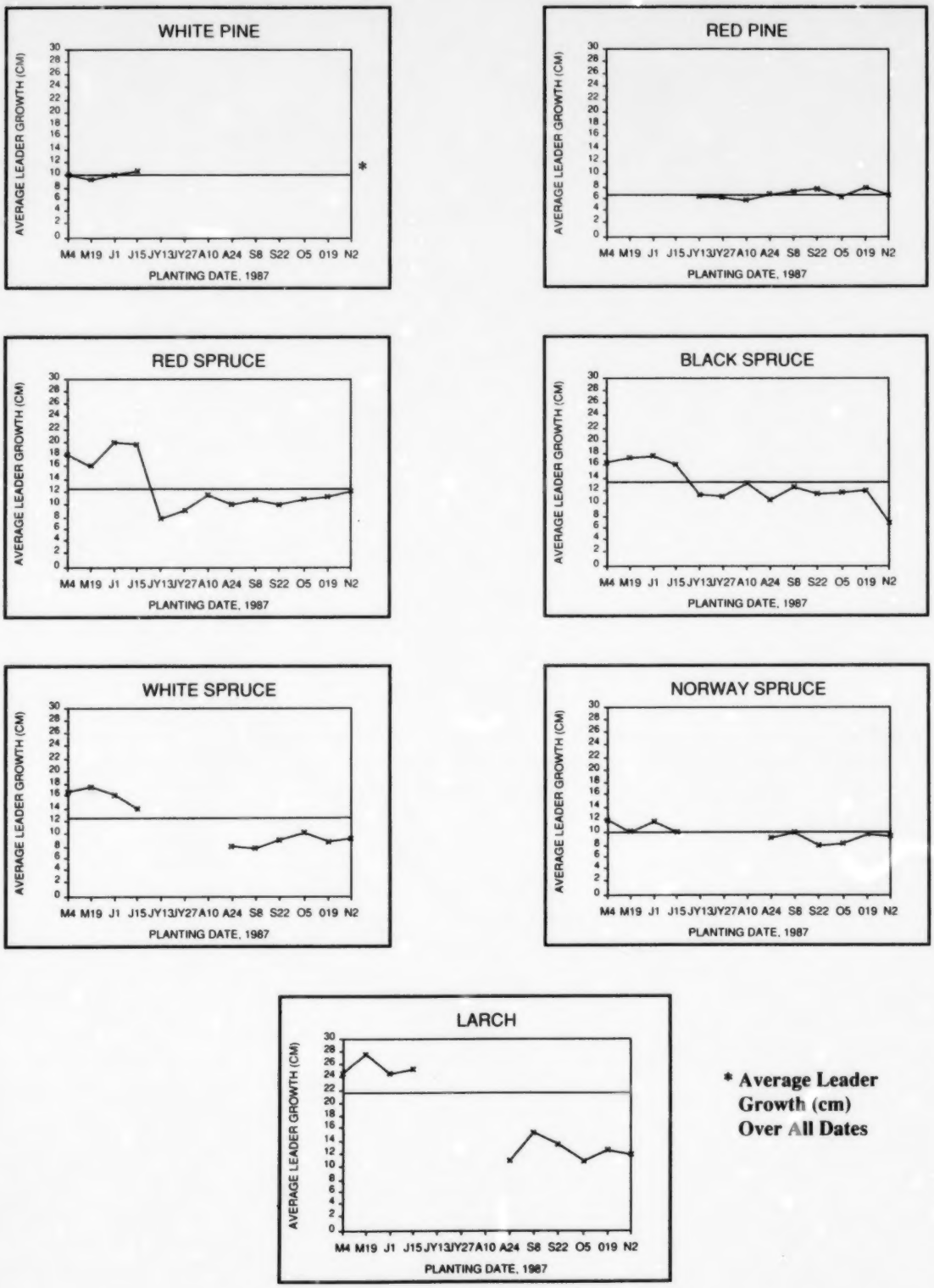


Figure 3. Average leader length (cm) by species and planting date, based on assessments conducted in November of the year following planting.

DISCUSSION AND CONCLUSIONS

Between June and September of 1987, mainland Nova Scotia experienced one of the driest periods on record in terms of total rainfall. Only 189 mm of rain fell during this period, as opposed to the 30 year average of 242 mm (Environment Canada, 1982). Despite these conditions, all of the species planted in this experiment showed no pronounced adverse affects on survival due to season of planting. In fact, survival averaged 86% over all species. Although these results suggest the 7 species included here could be planted from May until November, certain species were not planted during some sessions (see Table 1). Therefore no conclusions could be made about those species and planting session combinations. More specifically, Norway spruce, white spruce, white pine and eastern larch were not planted in the summer, red pine was not planted in the spring and white pine was not planted in the fall.

In addition, some operational and experimental red and black spruce plantations established in the fall of 1988 (one year after the fall plantings in this study) experienced higher mortality compared to spring and summer planted stock. This reduced survival and growth is attributed to severe winter drying (see Boyce, 1961) as a result of the combination of insufficient snow-cover and drying conditions in the winter following establishment (1988-1989). In contrast, the weather during the winter of 1987-1988 at Delaney Settlement produced adequate snow-cover; resulting in reduced desiccation of the newly established trees. In fact, the average snow cover during the months of December to March (1987-1988) was 21 cm versus 11 cm for the winter of 1988-1989 (based on climatological reports for Debert, Colchester Co.). Preliminary observations from a seasonal plantation experiment established in 1988 at the same location shows reduced red and black spruce survival when planted after September 1. On the other hand, Norway spruce, white spruce and red pine planted on the same site did not show adverse reaction to the winter conditions of 1988 when planted up to November.

On average, trees planted in the spring exhibited greater leader growth (by November of the year following establishment) than trees planted in the summer and fall; 16 cm versus 9 cm. This is attributed to the fact that fall planted seedlings had ceased height growth after outplanting in 1987. Therefore the leader growth measured in November 1988 was the first field grown leader, for the fall planted trees, whereas the leader growth measured on the spring planted trees represents their second year of growth in the field.

In conclusion, this study has shown that all species planted showed good survival irregardless of the planting season from early May to early November. However, it is recommended that red spruce be planted only until mid August, black spruce until the end of August and that the remaining species be planted only until mid September. This is a precaution necessary to minimize damage to planted stock during winter periods of inadequate snow cover.

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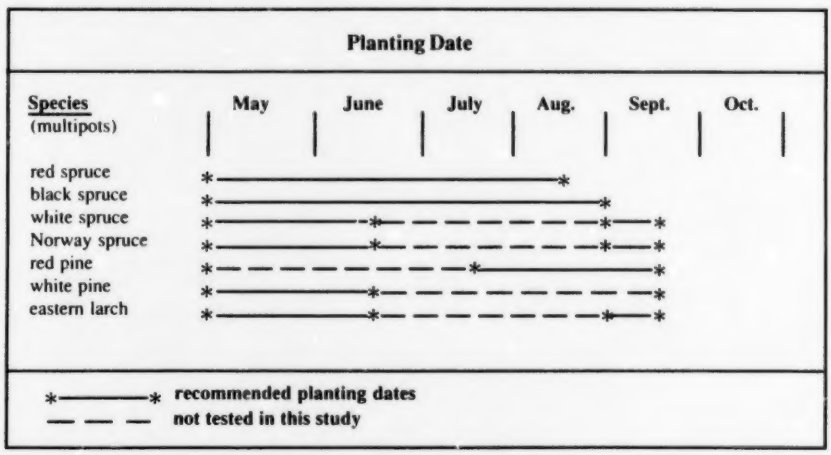
MANAGEMENT RECOMMENDATIONS

Based on the results of this experiment, preliminary recommendations for planting multipot-stock on coarse textured soils are as follows:



Limited operational testing of these results will be undertaken before finalizing planting recommendations.

APPENDIX I

Stock quality measurements for white, black, Norway and red spruce at the time of planting.

Planting Date	Avg. Height (cm)	Avg. R.C.D. (mm)	O.D. Weight (g)	S/R Ratio
Black Spruce				
May 4	21.5	1.73	19.0	4.23
May 19	25.8	1.65	23.7	7.15
June 1	27.3	2.25	26.0	5.43
June 15	28.3	1.80	24.0	7.00
July 13	*	*	*	*
July 27	23.0	1.93	18.9	5.75
Aug. 10	24.9	2.70	26.5	4.41
Aug. 24	24.0	2.02	19.0	3.09
Sept. 8	23.9	2.32	28.9	2.27
Sept. 22	22.7	*	24.8	3.03
Oct. 5	24.8	2.09	14.8	2.71
Oct. 19	23.1	5.11	28.5	2.74
Nov. 2	19.9	1.93	30.8	1.52
Average:	24.1	2.32	23.7	4.11
White Spruce				
May 4	21.4	2.11	2.22	3.19
May 19	23.9	2.50	34.2	3.75
June 1	22.7	2.56	25.0	4.00
June 15	33.0	2.33	36.7	5.30
Aug. 24	15.7	2.44	18.6	2.51
Sept. 8	17.1	2.48	21.8	3.95
Sept. 22	14.5	1.07	26.0	1.95
Oct. 5	17.0	2.67	33.1	1.67
Oct. 19	15.4	2.34	23.6	1.74
Nov. 2	15.3	2.35	31.0	1.70
Average:	19.6	2.29	27.2	2.98
Norway Spruce				
May 4	16.3	2.31	20.3	2.30
May 19	12.1	1.93	24.2	2.43
June 1	20.8	2.55	25.1	3.50
June 15	28.3	2.22	30.1	3.80
Aug. 24	17.6	2.21	15.5	2.88
Sept. 8	13.2	2.41	20.9	1.43
Sept. 22	15.9	*	24.6	1.86
Oct. 5	19.2	2.39	25.0	1.81
Oct. 19	18.0	2.48	28.0	1.75
Nov. 2	18.3	2.40	32.6	2.54
Average:	18.0	2.32	24.6	2.43
Red Spruce				
May 4	22.6	2.13	26.9	2.65
May 19	26.5	2.47	51.4	4.59
June 1	36.2	3.31	70.2	4.60
June 15	30.6	2.79	63.1	4.50
July 13	*	*	*	*
July 27	14.3	1.94	12.6	5.00
Aug. 10	21.4	2.68	*	*
Aug. 24	17.0	2.18	18.0	3.19
Sept. 8	21.2	2.31	26.6	2.13
Sept. 22	18.7	*	21.2	4.44
Oct. 5	21.7	2.40	28.7	2.26
Oct. 19	14.9	2.20	22.9	2.37
Nov. 2	21.0	2.10	27.8	3.48
Average:	22.2	2.41	33.58	3.56

Height - Seedling height (15 tree sample)
R.C.D. - Root collar diameter (15 tree sample)
O.D. - Total oven dried weight of shoots and roots
S/R - Ratio of O.D. shoot weight to O.D. root weight

* No data available

APPENDIX II

Stock quality measurements for red pine, white pine and eastern larch at the time of planting.

Planting Date		Avg. Height (cm)	Avg. R.C.D. (mm)	O.D. Weight (g)	S/R Ratio
White Pine					
May	4	13.2	2.33	41.7	1.76
May	19	13.0	2.16	38.2	2.08
June	1	19.9	3.55	50.0	1.70
June	15	22.3	3.03	40.7	2.70
Average:		17.1	2.77	42.7	2.02
Red Pine					
July	27	13.4	2.29	26.4	3.63
Aug.	10	15.7	2.16	31.5	3.04
Aug.	24	12.3	2.22	26.2	3.65
Sept.	8	11.3	2.39	31.0	3.13
Sept.	22	12.2	*	35.1	3.08
Oct.	5	13.7	2.59	38.8	2.80
Oct.	19	12.5	2.34	25.1	2.69
Nov.	2	12.4	2.02	28.1	2.85
Average:		12.9	2.29	30.3	20.1
Larch					
May	4	35.8	3.02	20.9	3.10
May	19	36.3	2.71	21.4	3.86
June	1	36.8	3.89	26.1	4.20
June	15	36.9	2.81	25.3	4.40
Aug.	24	23.0	2.39	14.4	2.00
Sept.	8	26.1	2.75	18.0	2.60
Sept.	22	26.1	*	17.2	2.91
Oct.	5	26.5	3.04	20.5	1.89
Oct.	19	24.3	2.91	18.5	2.03
Nov.	2	22.4	3.22	18.5	1.50
Average:		29.4	2.97	20.1	2.83

Height - Seedling height (15 tree sample)
R.C.D. - Root collar diameter (15 tree sample)
O.D. - Total oven dried weight of shoots and roots
S/R - Ratio of O.D. shoot weight to O.D. root weight

* No data available

APPENDIX III

Observed survival (%) by planting date, species and block based on assessments conducted in November of 1988.

OBSERVED SURVIVAL																	
	PLANTING DATE (1987)																
	May 4			May 19			June 1			June 15			July 13			July 27		
	BLOCK			BLOCK			BLOCK			BLOCK			BLOCK			BLOCK		
Species	23	25	5	2	29	8	15	28	4	12	21	30	33	38	40	32	34	36
wP	64	76	61	87	81	90	71	89	79	88	63	86		NP			NP	
rP		NP*			NP			NP			NP		73	68	84	86	79	81
wS	95	78	93	100	97	92	88	89	93	100	97	97		NP			NP	
rS	100	94	94	100	90	93	97	97	100	94	97	97	96	97	97	89	93	94
bS	88	87	92	92	98	91	99	95	84	98	93	95	97	90	94	100	97	100
nS	89	71	100	84	63	100	100	93	97	100	79	77		NP			NP	
eL	96	100	96	75	100	100	100	100	93	100	100	100		NP			NP	
Avg:	89	84	89	90	88	94	92	94	91	84	88	92	97	85	92	89	85	92

OBSERVED SURVIVAL																		
	PLANTING DATE (1987)																	
	Aug. 10			Aug. 24			Sept. 8			Sept. 22			Oct. 5			Oct. 19			Nov. 2		
	BLOCK			BLOCK			BLOCK			BLOCK			BLOCK			BLOCK			BLOCK		
Spec	31	39	42	14	20	6	10	16	24	11	18	9	19	26	27	17	3	7	1	13	22
wP		NP*			NP			NP			NP			NP			NP			NP	
rP	68	89	76	85	73	80	69	90	55	90	97	63	93	90	86	100	72	74	96	96	64
wS		NP		100	100	100	97	100	100	100	100	100	97	NP	100	100	100	100	100	100	100
rS	97	97	100	93	89	96	100	93	92	93	100	93	100	88	NP	100	NP	100	97	97	97
bS	98	94	NP	96	91	95	100	95	97	100	93	95	98	94	NP	97	98	95	94	100	94
nS		NP		100	96	94	93	100	97	100	100	96	100	97	100	100	97	100	100	100	100
eL		NP		100	96	89	100	100	96	100	100	100	100	NP	100	100	100	100	100	100	94
Avg:	88	93	88	96	91	92	93	96	90	97	98	91	98	92	97	100	93	95	98	99	92

APPENDIX IV

Projected survival (%) by planting date, species and block based on assessments conducted in November of 1988.

PROJECTED SURVIVAL																		
	PLANTING DATE (1987)																	
	May 4			May 19			June 1			June 15			July 13			July 27		
	BLOCK			BLOCK			BLOCK			BLOCK			BLOCK			BLOCK		
Species	23	25	5	2	29	8	15	28	4	12	21	30	33	38	40	32	34	36
wP	44	55	59	84	69	87	69	78	79	88	55	83		NP			NP	
rP		NP*			NP			NP			NP		63	56	81	66	66	79
wS	53	55	88	97	94	83	88	63	93	88	63	94		NP			NP	
rS	88	94	94	97	87	87	91	88	100	94	97	97	87	94	94	83	78	94
bS	84	79	87	90	93	84	97	92	84	98	92	94	97	84	94	100	94	100
nS	78	NP	100	81	50	100	94	90	97	100	69	75		NP			NP	
eL	87	84	77	76	88	100	100	100	93	100	97	97		NP			NP	
Avg:	72	73	84	88	80	90	90	85	91	95	79	90	82	78	90	83	79	91

PROJECTED SURVIVAL																		
	PLANTING DATE (1987)																	
	Aug. 10			Aug. 24			Sept. 8			Sept. 22			Oct. 5			Oct. 19			Nov. 2		
	BLOCK			BLOCK			BLOCK			BLOCK			BLOCK			BLOCK			BLOCK		
Spec	31	39	42	14	20	6	10	16	24	11	18	9	19	26	27	17	3	7	1	13	22
wP		NP*			NP			NP			NP			NP			NP			NP	
rP	60	86	73	77	73	67	67	88	39	81	93	46	83	82	69	100	72	53	89	90	58
wS		NP		93	100	97	97	97	100	93	100	93	97	NP	100	100	97	100	100	97	100
rS	91	97	100	87	83	96	100	91	82	93	100	93	100	85	NP	100	NP	94	97	97	97
bS	90	94	94	92	83	88	100	94	95	97	93	94	97	93	NP	95	98	94	84	96	88
nS		NP		90	87	94	84	97	94	100	100	87	100	94	100	100	97	100	100	100	96
eL		NP		90	87	81	97	100	81	100	97	89	50	NP	97	100	97	100	100	93	94
Avg:	80	92	89	88	86	87	91	95	82	94	97	82	86	89	89	99	91	88	95	96	89

* NOT PLANTED

APPENDIX V

Average leader length (cm) by planting date, species and block based on assessments conducted in November of 1988.

AVERAGE LEADER LENGTH (cm)																		
	PLANTING DATE (1987)																	
	May 4			May 19			June 1			June 15			July 13			July 27		
	BLOCK			BLOCK			BLOCK			BLOCK			BLOCK			BLOCK		
Species	23	25	5	2	29	8	15	28	4	12	21	30	33	38	40	32	34	36
wP	9	10	11	11	9	9	10	11	10	11	11	10		NP			NP	
rP		NP*			NP			NP			NP		8	6	5	6	6	6
wS	16	16	17	19	17	NP	16	13	19	12	11	18		NP			NP	
rS	17	20	17	17	17	NP	17	20	22	18	19	19	8	7	8	8	9	NP
bS	15	16	18	18	17	17	19	16	19	16	17	16	12	11	11	10	12	12
nS	11	11	13	11	8	11	11	9	15	8	11	13		NP			NP	
eL	26	20	27	32	26	24	27	22	NP	24	28	23		NP			NP	
Avg:	16	16	17	18	16	15	17	15	17	15	16	17	9	8	8	8	9	9

AVERAGE LEADER LENGTH (cm)																		
	PLANTING DATE (1987)																	
	Aug. 10			Aug. 24			Sept. 8			Sept. 22			Oct. 5			Oct. 19			Nov. 2		
	BLOCK			BLOCK			BLOCK			BLOCK			BLOCK			BLOCK			BLOCK		
Spec	31	39	42	14	20	6	10	16	24	11	18	9	19	26	27	17	3	7	1	13	22
wP		NP*			NP			NP			NP			NP			NP			NP	
rP	4	7	6	5	7	8	7	8	6	8	8	7	6	6	6	8	8	7	8	6	6
wS		NP		10	10	9	10	8	8	NP	9	10	11	10	NP	9	10	9	11	9	9
rS	11	10	13	9	9	11	8	10	11	9	9	10	10	11	NP	10	NP	11	14	NP	12
bS	13	13	15	11	11	12	14	11	14	11	12	13	13	13	NP	12	13	13	11	5	5
nS		NP		9	9	10	13	9	9	8	8	NP	8	8	9	NP	9	9	10	11	8
eL		NP		11	11	12	16	12	13	12	15	13	10	NP	11	12	14	12	10	12	14
Avg:	9	10	11	9	10	10	11	10	10	10	10	11	10	10	9	10	11	10	11	9	9

* NOT PLANTED

FOREST RESEARCH SECTION
FORESTRY BRANCH
N.S. DEPT. OF LANDS AND FORESTS

FOREST RESEARCH SECTION PERSONNEL

Technicians: Dave Arseneau, Steve Brown, George Keddy, Randy McCarthy, Keith Moore, Bob Murray, Peter Romkey, Ken Wilton
Chief Technician: Cameron Sullivan
Data Processing: Sylvia Chase, Eric Robeson
Foresters: Blair Andres, Brian Chase, Tim McGrath, Peter Neily, Tim OBrien
Supervisor: Russell McNally
Director: Ed Bailey
Secretary: Angela Walker